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Evolution of low-frequency contribution in emission of steep-spectrum radio sources

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Abstract. We consider evolution properties of galaxies and quasars with steep radio spectrum at the decametre band from the UTR-2 catalogue. The ratios of source's monochromatic luminosities at the decametre and high-frequency bands display the dependence on the redshift, linear size, characteristic age of examined objects. At that, the mean values of corresponding ratios for considered galaxies and quasars have enough close quantities,testifying on the unified model of sources. We analyse obtained relations for two types of steep-spectrum sources (with linear steep spectrum (S) and low-frequency steepness after a break (C+)) from the UTR-2 catalogue.

Keywords. Steep radio spectrum, decametre emission, galaxy, quasar

1. Introduction

We continue to study the properties of the steep-spectrum sources from the Grakovo decametre survey (UTR-2 catalogue) within the frequency range 10 to 25 MHz (Braude et al. 1978, Braude et al. 1979, Braude et al. 1981a, Braude et al. 1981b, Braude et al. 2003). This peculiar class of radio sources (the value of low-frequency spectral index exceeds 1) corresponds to conception of the long evolution, when the critical frequency of the synchrotron emission can displace to values less than 10 MHz. Befor (Miroshnichenko 2012a, Miroshnichenko 2012b, Miroshnichenko 2013) we received estimates of the main physical parameters of quasars and galaxies with steep radio spectrum over the sample of objects at the decameter band (at the frame of the Lambda-CDM model of the Universe). The sample of objects with linear steep spectrum (type S) includes 78 galaxies and 55 quasars with flux density more than 10 Jy at the frequency 25 MHz. The sample of objects with break steep spectrum (type C+) contains 52 galaxies and 36 quasars with flux density more than 10 Jy at the frequency 25 MHz. The optical and high-frequency data for examined sources have been got from the NED database. The redshift range of objects forms 0.017-3.570. Note, our calculations show that galaxies and quasars with steep low-frequency spectra have the great luminosity (by order of 10^{28} W/(Hz ster) at the frequency 25 MHz) and very extended radio structure with linear size by order of 1 Mpc, and characteristic age by order of 100 million years (Miroshnichenko 2012a, Miroshnichenko 2012b, Miroshnichenko 2013).

2. Contribution of decametre emission in sources with S-type and C+ - type of steep spectra

It is known that the decametre emission of galaxies and quasars corresponds to emission of their extended regions, outlying from source's core. At the same time, the source's emission at the higher frequencies, mainly, is connected with the emission from the central

Table 1. Mean values of the ratios of monochromatic luminosities at the different bands for quasars and galaxies with steep spectrum.

Mean value of ratio	**Quasars**	**Galaxies**
$< lg(S_25/S_5000) >$	1.69 ± 0.08	1.74 ± 0.05
$< lg(S_25/S_IR) >$	4.30 ± 0.11	$3.67 \pm 0.19)$
$< lg(S_25/S_opt) >$	5.00 ± 0.10	5.15 ± 0.12
$< lg(S_25/S_X) >$	7.78 ± 0.17	7.89 ± 0.33
$< lg(S_IR/S_X) >$	3.54 ± 0.20	4.68 ± 0.47

region of radio source. The ratio of low-frequency and high-frequency luminosities may be as characteristic of different substructures of objects indicating some features of their evolution. Moreover, one is not influenced by the Universe model. So, we determine the ratios of the flux densities of emission in the different bands: decametre (25 MHz), centimetre (5000 MHz), infrared (IR, K-band), optical (opt, V),X-ray (1 keV) band for quasars and galaxies from the steep-spectrum sample. These are identical to the ratios of the corresponding monochromatic luminosities (Table 1). It is important that the mean values of the corresponding luminosity's ratios for considered quasars and galaxies in Table 1 have enough close quantities. Thus, the obtained characteristics of sources with steep radio spectrum are in concordance with the unified model of sources.

We have received the relations for derived luminosity ratios of quasars and galaxies with spectrum S and C+ versus the redshift, linear size, characteristic age (see Fig.1-4). These relations evidence for the essential cosmological evolution of luminosities of steep-spectrum sources. The interesting picture is displayed in the relation of infrared and X-ray luminosities versus the linear size of sample objects (Fig. 2). The founded two branches in this relation may testify on the recurrence of the nucleus activity in galaxies and quasars with steep radio spectrum.

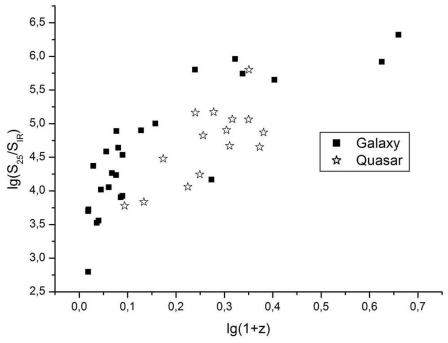

Figure 1. The ratio of monochromatic luminosities of examined sources at the decametre and infrared bands versus the redshift (for type S).

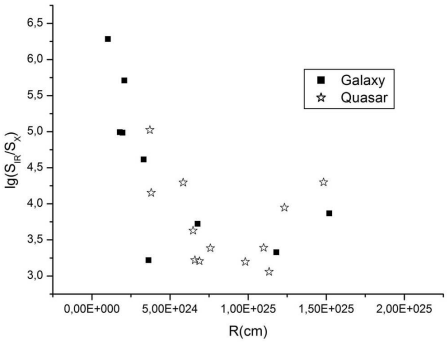

Figure 2. The ratio of monochromatic luminosities of examined sources at the infrared and X-ray bands versus the linear size (for type S).

3. Conclusions

Galaxies and quasars with steep radio spectrum display the essential cosmological evolution. The relative contribution of the decametre emission in steep-spectrum sources

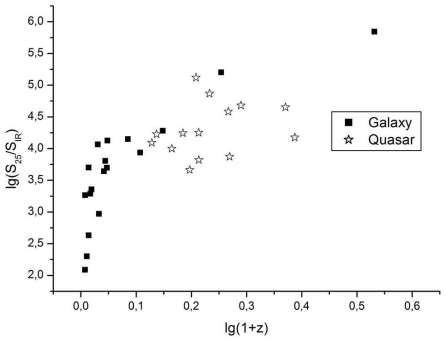

Figure 3. The ratio of monochromatic luminosities of examined sources at the decametre and infrared bands versus the redshift (for type C+).

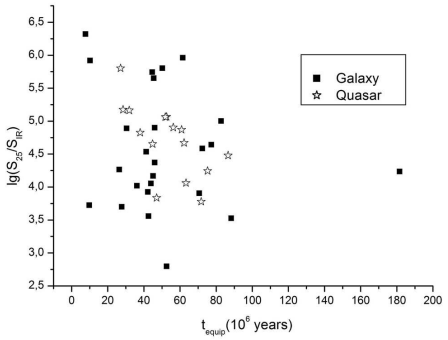

Figure 4. The ratio of monochromatic luminosities of examined sources at the decametre and infrared bands versus the characteristic age (for type S).

increases for more extended objects. The revealed two branches in relation of the ratio of infrared and X-ray luminosity versus the linear size of steep-spectrum galaxies and quasars may indicate on the activity recurrence of sources. Mutual similarity of the structure and the physical parameters of steep-spectrum galaxies and quasars corresponds to the unified model of sources.

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